

# Remote Sensing C

Rank: \_\_\_\_\_

Points: \_\_\_\_\_

Science Olympiad North Regional  
Tournament at the University of Florida



Name(s): \_\_\_\_\_

Team Name: \_\_\_\_\_

School Name: \_\_\_\_\_

Team Number: \_\_\_\_\_

Instructions: DO NOT BEGIN UNTIL GIVEN PERMISSION. DO NOT WRITE ON THIS EXAM. All work should be shown on the answer sheet. You will have 50 minutes to complete the exam. You may separate the test.

Allowable materials: Scientific Calculator, Pens and Pencils, Rulers and Protractors, Four (4) 8.5" x 11" note sheets

## PART 1: REMOTE SENSING INSTRUMENTATION AND PHYSICS (25%, 42 pts)

1. Which of the following can be accomplished using LiDAR technology? Select all that apply. **(3 pt)**
  - A. Elevation measurements
  - B. Calculating rock density
  - C. Obstacle detection
  - D. Calculating height of vegetation
  - E. Quantum-mechanical observations
2. What are the advantages of LiDAR over RADAR? **(1 pt)**
  - A. LiDAR provide images with less noise
  - B. LiDAR is a passive sensor
  - C. LiDAR are less expensive instruments
  - D. All the above
  - E. None of the above
3. Identify the incorrect statement. **(1 pt)**
  - A. A perfect blackbody absorbs all incident radiation without reflecting any
  - B. To stay in thermal equilibrium, a blackbody must emit radiation at the same rate that it absorbs it
  - C. A blackbody at a uniform temperature displays a characteristic frequency distribution that depends upon its density
  - D. Black holes are near-perfect blackbodies
  - E. Simple models of planetary energy balance approximate a planet as a perfect blackbody
4. Which type of scattering is responsible for the red appearance of the sky during sunrise and sunset? **(1 pt)**
  - A. Rayleigh scattering
  - B. Nonselective scattering
  - C. Mie scattering
  - D. Raman Scattering
5. What type of scattering is responsible for the white glare around the sun? **(1 pt)**
  - A. Rayleigh scattering
  - B. Nonselective scattering
  - C. Mie scattering
  - D. Raman Scattering
6. Which of the following is not a cause of Mie scattering? **(1 pt)**
  - A. Pollen
  - B. Dust
  - C. Smoke
  - D. Ozone
  - E. Water droplets
7. Which describes MODIS instruments? **(1 pt)**
  - A. Monochromatic
  - B. Panchromatic
  - C. Multispectral
  - D. Superspectral
  - E. Hyperspectral
8. Which of the following is NOT an advantage to LiDAR over RADAR? **(1 pt)**
  - A. Higher spatial resolution
  - B. Can operate in the presence of cloud cover
  - C. Less beam divergence
  - D. Can detect smaller objects
9. Clouds directly affect the Earth's energy balance by **(1 pt)**
  - A. Reflecting incoming sunlight back into space
  - B. Absorbing and emitting reflected light back into space
  - C. Both A and B
  - D. Clouds do not affect the Earth's energy balance in any way
10. The radiant energy flow per unit volume is called what? **(1 pt)**
  - A. Brightness
  - B. Radiant Flux Density
  - C. Intensity
  - D. Volumetric Exitance
11. Why is the sky blue? Make sure to describe the mechanism in detail. **(2 pts)**

12. What is the difference between active and passive sensors? **(2 pts)**

An electromagnetic wave has a wavelength of 2.00 micrometers. Use this information to answer questions 13-17.

13. What is its frequency? **(1 pt)**

14. What is the energy of a photon in Joules? **(1 pt)**

15. What is the energy of a photon in electron-volts? **(1 pt)**

16. What type of electromagnetic radiation is it? **(1 pt)**

- A. Near-infrared
- B. Short-wavelength infrared
- C. Mid-wavelength infrared
- D. Long-wavelength infrared
- E. Thermal infrared
- F. Far infrared
- G. This is not infrared radiation

17. What features can it be used to distinguish? **(1 pt)**

- A. Clouds
- B. Snow
- C. Ice
- D. All the above
- E. None of the above

18. What is the power output of a sphere with a radius of 2.20 meters and a temperature of 100.°C? **(2 pts)**

The temperature of the sun is 5,778K. Use this information to answer questions 19-21.

19. What is the peak wavelength emitted by the sun? **(1 pt)**

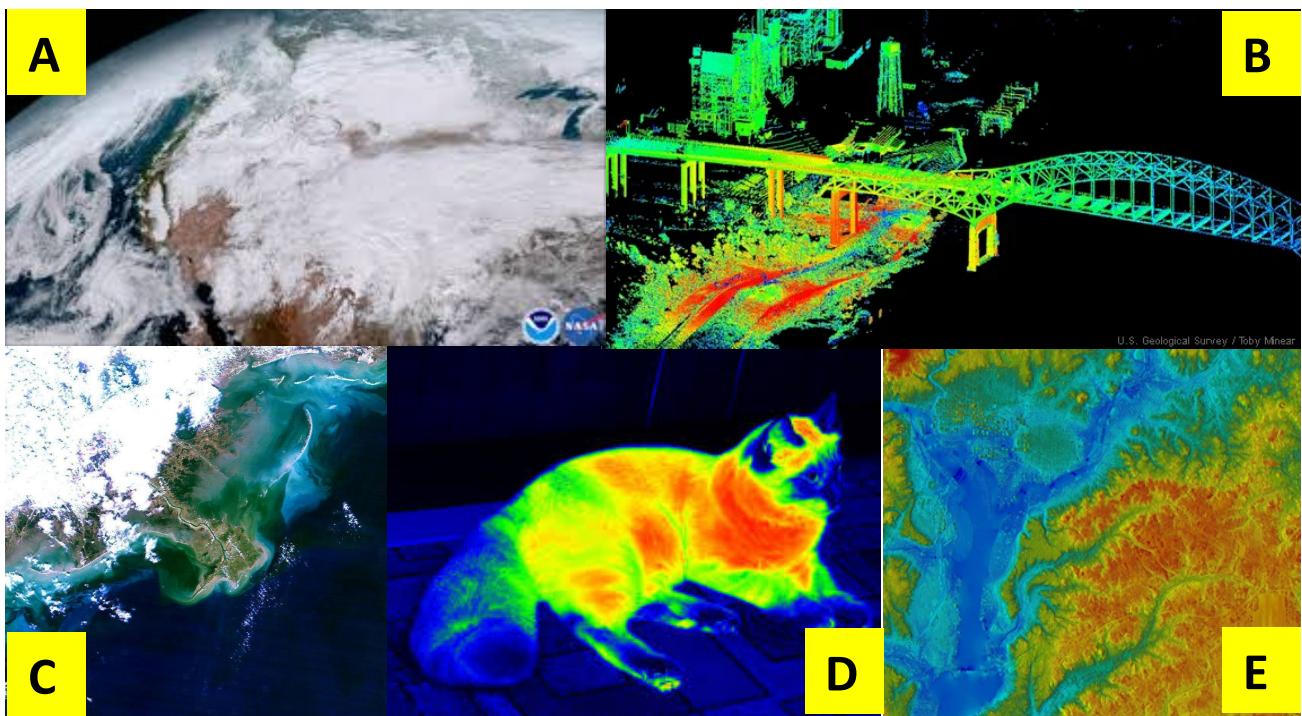
20. What type of radiation is this? **(0.5 pts)**

21. Is this the only type of radiation emitted by the sun? **(0.5 pts)**

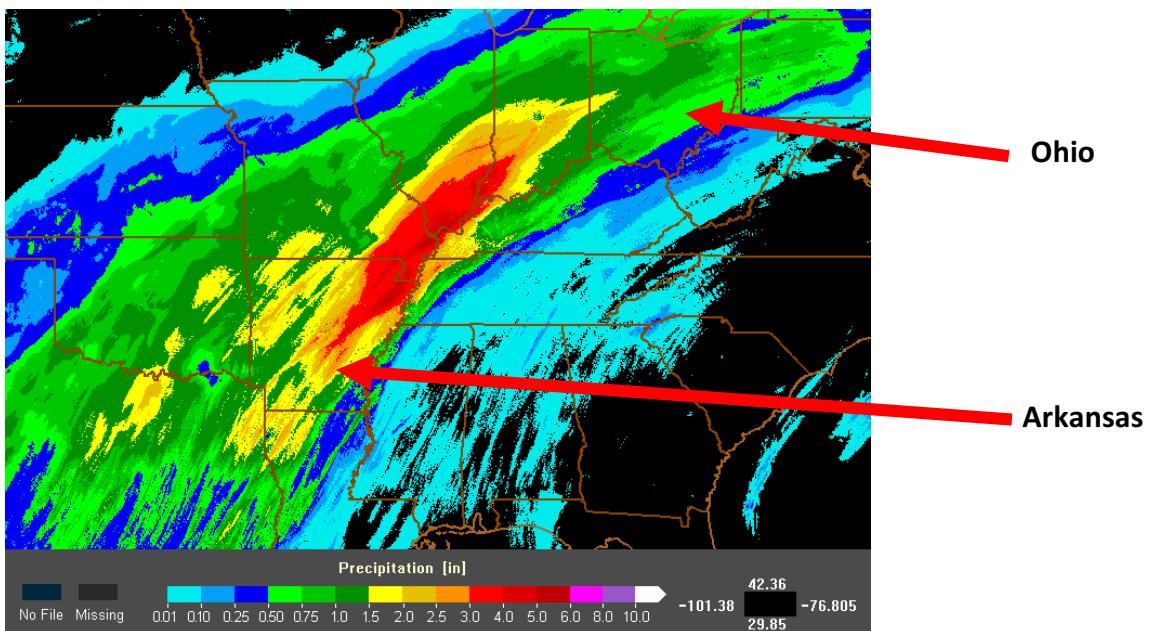
22. A LiDAR positioned on an aircraft is being used to take measurements of the elevation of different parts of Mt. St Helens.

- A. In addition to the LiDAR, what other sensor is necessary to create a 2-dimensional model of the various elevations of the mountain? **(2 pts)**
- B. The time-of-flight (TOF) of a LiDAR measurement is the difference in time between when a pulse is sent and backscatter is received. If the TOF of a particular measurement is 33.0 micro-seconds (us), what is the elevation of that part of the mountain if the aircraft is 10,500 meters above sea-level? **(3 pts)**

23. Identify the following images as being taken by an active sensor or a passive sensor. (5 pts)



Answer questions 24 and 25 based on the image below. The values in the key are given in inches per hour.



24. Assuming that the rate of precipitation and location remains constant, calculate the approximate volume of rain (in cubic inches) that will fall over Ohio in an hour given that Ohio is 44,824.90 square miles. (6 pts)

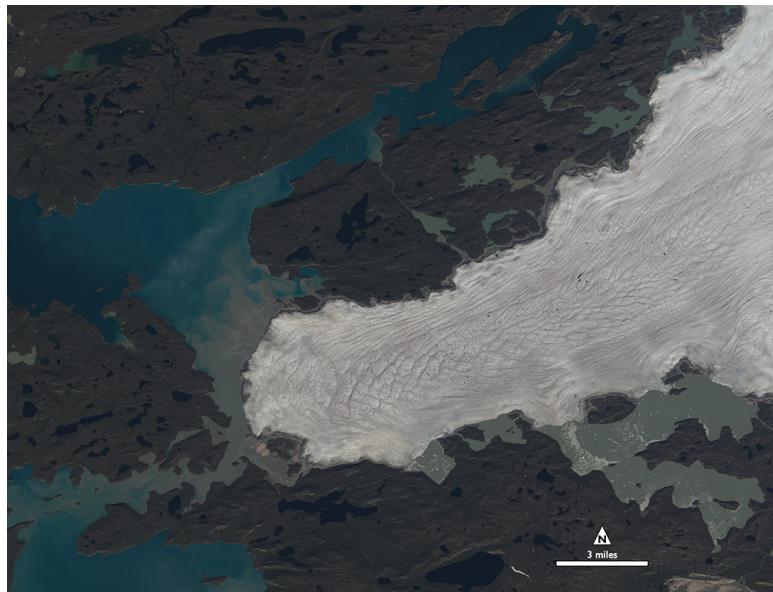
25. What type of instrument was used to gather the data to create this image? (1 pt)

## PART 2: IMAGE INTERPRETATION (28%, 48 PTS)

Use the image to the right to answer questions 26-32. (16 pts total)

26. What color rendering is this image presented in? (1 pt)
27. State the instrument that took this image. (1 pt)
28. What is the white area in the image? (1 pt)
29. Approximate the area (in miles-squared) of the white area. (2 pts)
30. Approximate the average albedo of the entire area of the image given the following table. (3 pts)

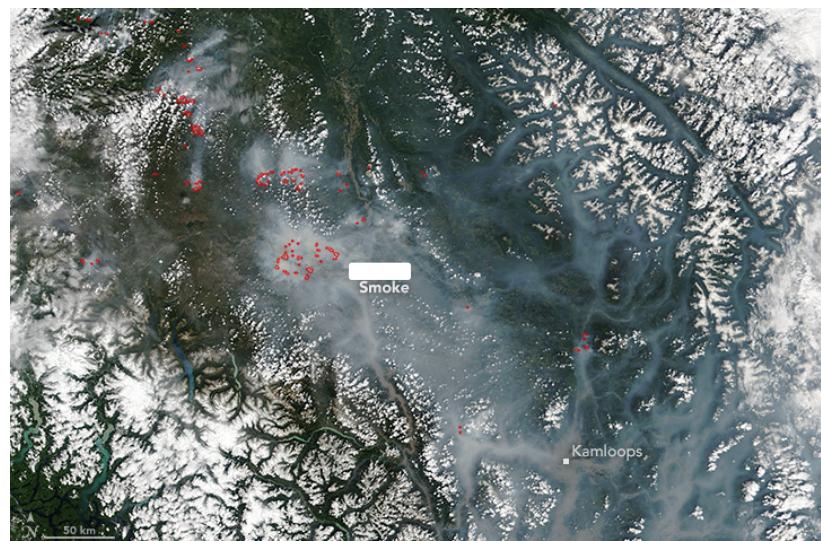
Surface	Albedo
Open ocean	0.06
Conifer forest	0.09
Deciduous trees	0.16
Bare soil	0.17
Green grass	0.25
Desert sand	0.40
Ocean ice	0.50



31. This image was taken in southeast Greenland. What process can be observed in this image? (3 pt)
32. State whether the process you provided in #31 contains a positive, neutral or negative feedback loop and describe the process including all relevant steps (if applicable). (5 pt)

Use the provided image to answer questions 33-37. (5 pts total)

33. What color rendering is this image presented in? (1 pt)
34. State the instrument that took this image. (1 pt)
35. What are the solid white parts in the image? (1 pt)
36. What are the transparent white parts in the image? (1 pt)
37. What do the red dots in the image indicate? (1 pt)



Answer questions 38-45 using your knowledge on the Topex-Poseidon satellite and the images provided. (8 pts total)

38. What was the Topex-Poseidon satellite intended to measure? (1 pt)



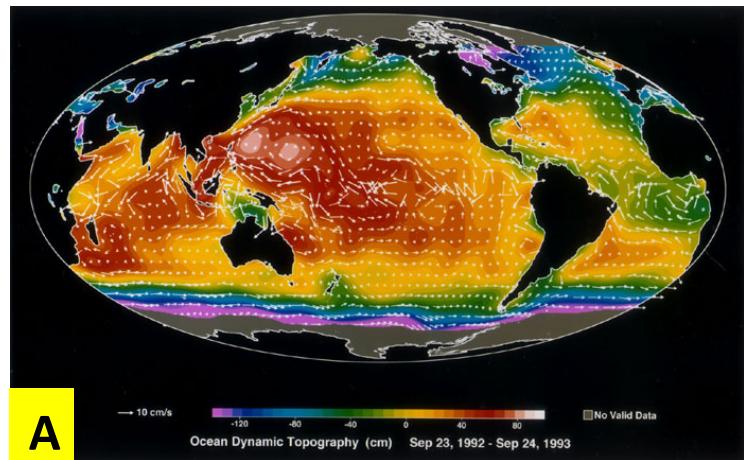
39. To what degree of accuracy was the Topex-Poseidon satellite able to take measurements? (1 pt)

- A.  $\leq 1\text{cm}$
- B.  $\leq 5\text{cm}$
- C.  $\leq 10\text{cm}$
- D.  $\geq 15\text{cm}$

40. What did the satellite mission improve our understanding of? (1 pt)

41. What is the name of the instrument shown in image B? (1 pt)

42. What is being shown by the colors in image A? (1 pt)



43. What color rendering is image A presented in? (1 pt)

44. What is the predominant cause of the phenomena shown in image A? (1 pt)

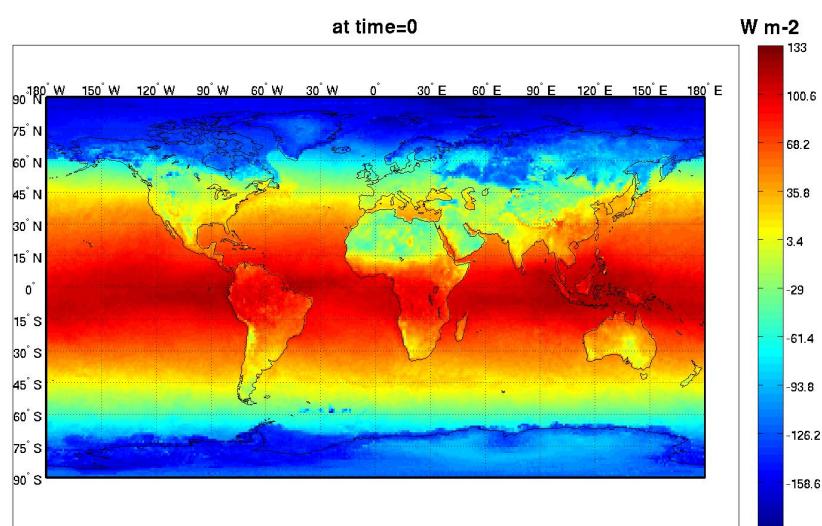
45. What do the white arrows in image A depict? (1 pt)

The image below shows the net radiant flux (power) received by the Earth's surface per unit area. Answer questions 46-48 using the image provided. (8 pts total)

46. State the instrument that was used to create this image. (1 pt)

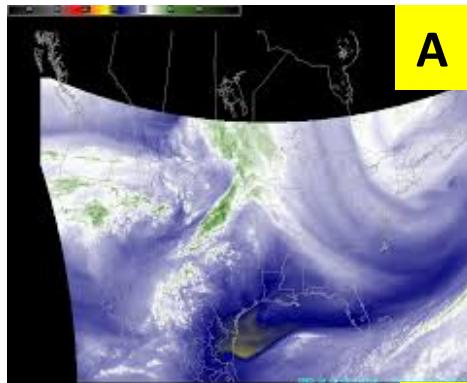
47. State two reasons why the equator has a higher net radiant flux than the poles. (4 pts)

48. Why do Northern Africa and the Middle East have unusually lower net radiant fluxes than characteristic of the regions surrounding them? (3 pts)



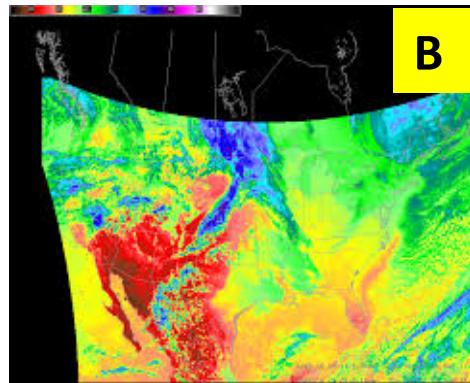
Answer questions 49-56 using the images provided. (11 pts total)

49. Identify the satellite that took these images. (1 pt)



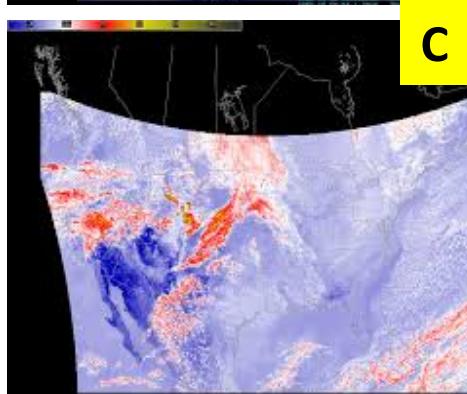
**A**

50. Which image(s) (if any) is/are displayed using a true-color rendering? (1 pt)



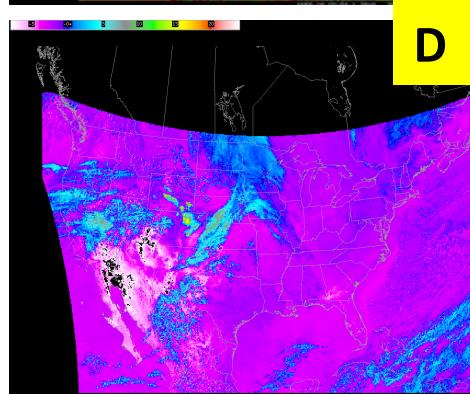
**B**

51. Which image(s) (if any) is/are displayed using a false-color rendering? (1 pt)



**C**

52. Which image(s) (if any) is/are displayed using a pseudo-color rendering? (1 pt)



**D**

53. What colors are used to generate image C? (3 pts)

54. What accounts for the deep blue in image C and deep red in image B? Hint: Infer based on the geography in the region. (2 pts)

55. Why does image C contain black speckles over Minnesota and North Dakota? Hint: They aren't supposed to be there. (2 pts)

### PART 3: CLIMATE PROCESSES AND CLIMATE CHANGE (23%, 39 PTS)

56. Which of the following is NOT true about global warming and greenhouse gases? (1 pt)

- A. Fossil fuel consumption is increasing the quantity of greenhouse gases in the atmosphere
- B. Greenhouse gases contribute to global warming by trapping heat in the atmosphere
- C. Photosynthesis decreases the concentration of greenhouse gases in the atmosphere by absorbing CO<sub>2</sub> and converting it into O<sub>2</sub>
- D. Logging and clearing forests is contributing to the onset of global warming
- E. Greenhouse gases are the only contributing factor to global warming

57. Which of the following is not a greenhouse gas? **(1 pt)**

- A. H<sub>2</sub>O
- B. CO<sub>2</sub>
- C. CH<sub>4</sub>
- D. N<sub>2</sub>O
- E. O<sub>3</sub>
- F. H<sub>2</sub>

58. Which of the following is the most potent greenhouse gas? **(1 pt)**

- A. H<sub>2</sub>O
- B. CO<sub>2</sub>
- C. CH<sub>4</sub>
- D. N<sub>2</sub>O
- E. O<sub>3</sub>
- F. H<sub>2</sub>

59. Which of the following is the greenhouse gas of greatest concern due to its long atmospheric lifetime? **(1 pt)**

- A. H<sub>2</sub>O
- B. CO<sub>2</sub>
- C. CH<sub>4</sub>
- D. N<sub>2</sub>O
- E. O<sub>3</sub>
- F. H<sub>2</sub>

60. Which of the following is NOT true regarding clouds? **(1 pt)**

- A. Clouds reflect a portion of solar radiation back into space
- B. Clouds intercept part of the thermal infrared radiation emitted by the surface and atmosphere
- C. Clouds have an overall heating effect on the atmosphere
- D. Clouds emit visible solar radiation

61. List the following steps of cloud formation in order of occurrence. **(2 pts)**

- A. Saturation point is reached and extra water vapor condenses
- B. Warm air rises and expands
- C. A cloud is formed when enough moisture is condensed out of the air parcel
- D. Air pressure drops and cools
- E. Sun heats the ground consequently heating the air
- F. Air parcel continues to rise and moisture continues to condense

62. Which of the following are steps in the carbon cycle? Select all that apply. **(2 pts)**

- A. Combustion
- B. Respiration
- C. Photosynthesis
- D. Deposition
- E. Assimilation

63. Which of the following is NOT a factor that GWP depends on? **(1 pt)**

- A. Absorption of infrared radiation by the given species
- B. Spectral location of the species' absorbing wavelengths
- C. Mass of the species
- D. Atmospheric lifetime of the species

64. Which of the following is not a common time interval over which GWP is calculated? **(1 pt)**

- A. 50 years
- B. 100 years
- C. 500 years

65. Transpiration rates of plants (increase/decrease) with CO<sub>2</sub> increase. **(1 pt)**

66. Transpiration rates of plants (increase/decrease) with temperature increase. **(1 pt)**

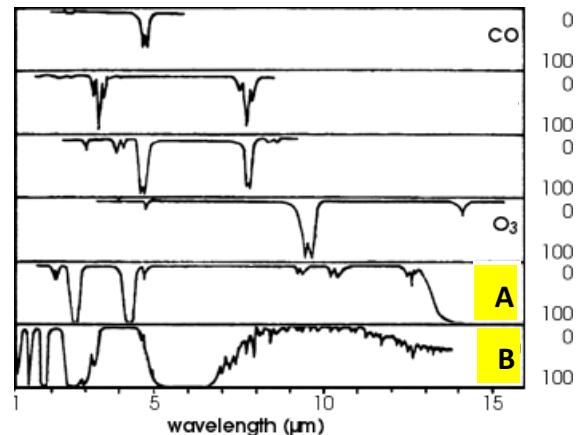
67. Name two natural sources of greenhouse gases in addition to one of the gases that it releases. **(2 pts)**

68. Name two anthropogenic sources of greenhouse gases in addition to one of the gases that it releases. **(2 pts)**

69. Describe the direct effect of aerosols on the atmosphere and indicate whether it leads to atmospheric cooling or heating. (2 pts)
70. Describe the indirect effect of aerosols on the atmosphere and indicate whether it leads to atmospheric cooling or heating. (2 pts)
71. What is Global Warming Potential? (1 pt)
72. The GWP of N<sub>2</sub>O is 121.0. Calculate the equivalent mass of 10kg of N<sub>2</sub>O in tonnes of CO<sub>2</sub>. Hint: 1 tonne is equal to 1,000kg. (3 pts)
73. Changes in sea surface salinity are tracked by monitoring the relationship between which two steps of the hydrologic cycle? (2 pt)
74. Where does the lowest sea surface salinity occur? (1 pt)
75. Where does the highest sea surface salinity occur? (1 pt)
76. True or false? Evaporation from the sea surface partially cools the surface of the ocean. (1 pt)
77. True or false? The ocean absorbs heat from the atmosphere and serves as a partial buffer to the greenhouse effect. (1 pt)

Use the atmospheric absorption spectra plot below to answer questions 78-81.

78. What type(s) of electromagnetic radiation is absorbed the most by the CO in the atmosphere? Be specific for full credit. (2 pts)
79. What type(s) of electromagnetic radiation is absorbed the most by the O<sub>3</sub> in the atmosphere? Be specific for full credit. (2 pts)
80. Identify gas A based on its absorption spectrum. (2 pts)
81. Identify gas B based on its absorption spectrum. (2 pts)



## PART 4: ENERGY BALANCE (24%, 40 pts)

82. Create a simple expression approximating the energy radiated by the earth per second given the following. Answer should be expressed in J/s (Joules per second) or in W (Watts). (5 pts)
- Surface Area of a sphere: SA =  $4\pi R_E^2$  ( $R_E$  = radius of the Earth)
  - Stefan-Boltzman law: Energy flux =  $\frac{P}{A} = \sigma T^4$

83. Create a simple expression approximating the incident energy absorbed from the Sun by the Earth per second given the following. Do not incorporate albedo and the greenhouse effect. (5 pts)

- Solar Flux:  $F_S$
- Area of a circle:  $A = \pi R_E^2$  ( $R_E$  = radius of the Earth)

84. The Earth is in thermal equilibrium thus incident energy must equal radiated energy. Set  $E_{IN} = E_{OUT}$  and solve for  $T_{eff}$ , the effective temperature of the Earth, given the following values. Express your answer in degrees Celsius. (10 pts)

- Solar Flux:  $F_S = 1379 \text{ W/m}^2$
- Radius of the Earth ( $R_E$ ) =  $6.371 \times 10^6$  meters
- Stefan-Boltzmann constant:  $\sigma \approx 5.670 \times 10^{-8}$

85. To improve the approximation, incorporate the Earth's albedo into the equation for the incident energy absorbed by the Earth from the Sun given the following. Using this new equation for  $E_{IN}$ , calculate the new value for  $T_{eff}$ , the effective temperature of the Earth. (5 pts)

- Albedo:  $\alpha = 0.30$

86. Given that the Earth's global average temperature is approximately  $14.8^\circ\text{C}$ , is this prediction more or less accurate than that of the first model? (2 pts)

87. Incorporate the effect of greenhouse gases on the energy radiated by the Earth using a dimensionless parameter  $\varepsilon$ .  $\varepsilon$  is the greenhouse factor, which models the effect of greenhouse gases on the permittivity of the atmosphere and must fall in the range  $0 < \varepsilon < 1$ . Taking  $\alpha = 0.30$  as before, what value of  $\varepsilon$  correctly predicts the Earth's global average temperature of approximately  $14.8^\circ\text{C}$ ? (10 pts)

88. Explain how the value of  $\varepsilon$  effects the predicted global equilibrium temperature. That is, how does raising or lowering  $\varepsilon$  effect  $T$ ? (3 pts)